PIEZOELECTRIC/ELECTROSTRICTIVE FILM ELEMENT FORMED AT LOW TEMPERATURE USING ELECTROPHORETIC DEPOSITION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a piezoelectric/electrostrictive film element formed by a method using an ultrafine ceramic oxide powder and electrophoretic deposition. In particular, the present invention relates to a piezoelectric/electrostrictive film element formed at low temperature by way of electrophoretic deposition using an ultrafine ceramic oxide powder having excellent reactivity and produced by a single process at low temperature.

Description of the Prior Art

Unit particle micronization and uniformity of particle diameter distribution are emphasized in ceramic oxide powder which is a raw material of various devices using the ceramics such as an ink jet head, memory chip, and piezoelectric substance. This is because, in case of finer particles, the activation energy can be lowered by surface treatment and the reactivity and applicability can be improved by particle electrification.

So far the method has been used where a ceramic sol with controlled viscosity or a ceramic oxide powder regenerated by a suitable solvent is fixed at

the substrate in order to form a piezxoelectric/electrostrictive film element in a manufacturing method of various film devices using the ceramics.

Considering the ultimately obtained film quality, methods mainly used for the ceramic sol solution are dip coating, spin coating, electrochemical oxidation/reduction etc. while methods used for the ceramic oxide powder are various printing, molding, electrophoretic deposition (ERD) etc.

Among these methods, EPD is a method to mold an elaborate film, making use of the polarization of each component by electric polarity and the stacking property of solid particles.

In the EPD process using a ceramic oxide powder, shown in block diagram form in Figure 2, ceramic particles of average diameter not less than 1 μm made by a solid phase process are dispersed in an adequate dispersion medium of water or organic dispersed in adequate dispersion medium of water or organic dispersant. Then, they are mixed with a pH-controlling medium to make a sol solution controlled in surface electric charge, which the colloidal suspension is used for ceramic to move to a cathode or anode to form a film on a substrate. This film is vapor deposited by thermal treatment above 1000°C, eventually to, form the film.

EPD like this has an advantage to make a high quality film unrestricted in area or thickness, using a simple equipment.

But a separate operation is needed to disperse powder using a dispersant, in order to secure dispersibility because a large particle diameter powder is used. Also, there is inevitability a problem of high temperature thermal treatment to get material property peculiar to the ceramic, because the formed film property is similar to the bulk.

SUMMARY OF THE INVENTION

The present invention, to solve the problems, has a purpose of providing a method to form a piezoelectric/electrostrictive film element through electrophoretic deposition and thermal treatment at low temperature using ultrafine ceramic oxide powder, which is excellent in reactivity and has very fine particle size, as it has been made by a single process at low temperature by a combustion method using citric acid as a combustion aid.

The present invention to achieve the purpose, provides a piezoelectric/electrostrictive film element formed at low temperature using electrophoretic deposition, by the method comprising the steps of: preparing a solution or a dispersed mixture containing constituent ceramic elements by dissolving or dispersing the raw material of constituent ceramic elements in a solvent or a dispersion medium; preparing a mixed solution by adding citric acid into the solution or the dispersed mixture in which the constituent ceramic elements are dissolved or dispersed; getting ultrafine ceramic oxide powder of particle size less than 1 μm with uniform particle diameter size distribution, by forming ceramic oxide without scattering over, by a nonexplosive oxidative-reductive combustion reaction by thermally treating the mixed solution at 100-500°C; preparing a suspension by dispersing the ultrafine ceramic oxide powder in an organic dispersant; preparing a ceramic sol solution by dissolving constituent ceramic elements of the same or similar constituent as the ultrafine ceramic oxide powder in water or an organic solvent; dispersing by mixing with the ceramic sol solution the suspension in which the ultrafine ceramic oxide powder is dispersed; forming a piezoelectric/electrostrictive film element by submerging a substrate into the suspension in which the ultrafine ceramic oxide powder and the ceramic sol solution are mixed and then performing electrophoretic deposition; and thermally treating the piezoelectric/electrostrictive film element at 100-600°C, so that the solvent is removed by the thermal treatment and bonding among the ultrafine